Result Page

The invention refers to an adaptive image processing system for classifying of parts which can be examined on the basis captured images, become extracted from which features, which become essentially treated within an image processing the data reduction. The system is adaptive, so that its use consists of a learning phase and a test phase. The learning phase several patterns of parts become provided, which are typical in each case for a predetermined Entscheidungskl. Thus the image processing system can become variable operated.

The starting situation is to accelerate the use and the Parametrierung of the technical image processing in principle and make thus other cases of application possible. It is to be marked that the technical image processing takes a key position fü the always strong becoming automation efforts. This refers in particular to the quality assurance when assembly assembling, with the recognition of parts or with the monitoring. Fast parametrierbare systems supply a time and a competition advantage. With the here considered image processing parts must become on the basis specific features, like form, color and contours recognized and/or. the quality of known parts must become on the basis these criteria judged or discriminated. The object of the image processing and the pattern recognition is thereby classifying the parts on the basis characteristic sets, which become from the image gained by picture preprocessing and characteristic extraction.

Only a relative small portion of all potential application type of the image processing in the industry was so far opened. Causes for it are essentially the flexibility lacking of many methods, which besides little robust are. With the industrial use however the difficulty of the adaptation at new environmental conditions or objects exists. A user-friendliness lacking is exactly the same as to high costs a disadvantage for the use of powerful systems. Thus such an image processing system cannot be amortized fast in many cases.

Standard image processing systems, as for example the VIDEOMAT IV (of Siemens, Munich and Berlin, Germany) solve this object by sequential execution of a test program, which consists of test sections with standardized test elements. This connection is general in Fig. 1 shown, whereby the test program the entire process accompanied. At the beginning of each procedure the image pickup stands, whereupon from the captured images the picture characteristics become extracted. Only these picture characteristics form the input data for a classifying.

The test program and the test elements can be parametriert by the user task specific created and. This means in particular that features or class organizations become direct formed following the object which can be furnished formulated or. Bottom Parametrierung becomes in particular a procedure understood, which specifies several parameter within a test system or a temporary. Classifying always forms the conclusion of the test program and becomes by a decision table realized. This table accomplishes classifying due to a predetermined arithmetical and/or logical linkage of the feature values. Since classifying makes the assortment in decision classes as last member of the image processing chain, a critical meaning for the function of an image processing system is attached to this step.

Generally after a picture characteristic extraction the patterns (learning phase) become by a n-dimensional feature vector f= (f1, f2. . . , fN) T in the characteristic area represented. See for this Fig. 2. By classifying the patterns the so-called become. Decision classes assigned; K, L, M. . . . Usually pattern forms the same class so-called. Cluster in the characteristic area and classifying have the object to define the classes in optimum manner from each other which a minimization of the false alarms and/or. equals the error rate with the assignment from parts to corresponding decision classes.

The existing approaches for the execution of classifying are usually based on the statistical decision theory and optimize the Klassifikator (part of the test program) due to the statistic in the characteristic area. These approaches do not have themselves in the practice sufficient preserved, since frequent no A priori probabilities over the features, which are necessary to the Parametrierung of the Klassifikators, fixed to become to be able. Differently expressed can be to small the number of the patterns known class affiliation, in order to compute the probability distribution in the characteristic area with sufficient security from the signal statistics. In addition the characteristic statistics strong depends on the process of the generation of characteristic and can vary for example with changed environmental conditions (illumination, positioning of the objects and similar) strong.

The invention is the basis the object to make an adaptive image processing system available by means of which a faster Parametrierung of the image processing possible will and which becomes use in production extended.

The solution is done via the features of the claim 1.

The invention is the basis the finding that the Klassifikator contained in the test program can parametrieren itself. The invention describes therefore an adaptive system for automatic classifying and partial recognition. This system parametriert itself from patterns of all decision classes of the learning phase and independent of an explicit characteristic statistics, which would meet a decision to a sample class. This system an allowed automatic recognition or classifying of parts from a presentation of some representative examples. By the automatic Parametrierung the system thereby can

become problem-free and flexible also on new sample classes or Umgebungsbedingun matched.

The rear presentation of a dividing and/or. Musterauswahl from the various for the decision classes typical patterns in the learning enterprise becomes an automatic image pickup ready rack a Klassifikator a contained test program of generated automatic picture characteristics. These extracted features become stored in a characteristic data base for all patterns of the sample. A normalization and a scaling of the features provide for an uniform area, are placed within which all extreme values. Further the number of the patterns put down in the database, as well as the number of the features become reduced. Thus only such patterns and such picture characteristics are present, which are relevant for classifying. After conclusion of a learning phase the automatic examination of unknown patterns can take place to the inspection and for partial recognition in the test phase.

Around an eventual repetition of the learning phase without renewed image pickup the image data in a graphic data bank, received of the presentation of the parts, will grant deposited in each case for the archiving of the images and the associated decision classes (sample). Automatic classifying of the patterns from the characteristic data base can be in advantageous manner with determination of a reliability value of the Klassifikators linked.

In the following an embodiment becomes described on the basis the schematic figs.

Fig. 1 shows the test sequence with standard image processing systems to the state of the art,

Fig. 2 shows the sample distribution and the decision classes in the n-dimensional characteristic area,

Fig. an image processing system points 3 to automatic classifying the corresponding invention.

Fig. 1 shows, as already mentioned, a standard picture work International Telecommunication Union system, which usually solves the given object by sequential execution of the test program, whereby the test program consists of test sections with standardized test elements.

Fig. the representation of patterns shows 2 after the characteristic extraction, those generally by n-dimensional feature vectors I< i> in the characteristic area shown become. There is in a cutout of the characteristic area decision classes K, L and M indicated. A new on dipping pattern A receives a feature vector I< A> . This pattern is to be assigned to the existing decision classes. , The pattern the same class is to be marked to clusters within the characteristic area usually forms and classifying has the object to define the classes in optimum manner from each other. Further it is to be noted that the number in a Entscheidungskla included patterns, those in each case a feature vector I< i> associated is, minimized will is, in order to limit the cost of computation. It applies thus to make within a limited cutout of the characteristic area a meaningful distribution of the decision classes and to accomplish the Parametrierung of the Klassifikators with a necessary however minimum number of Muste and features in the learning phase. Case the reliability of the Klassifikators after the learning phase yet sufficient is not, then the Parametrierung can become (eventual with changed characteristic extraction) again performed at any time. If the minimization of the patterns is for example completed not yet to the end of the learning phase, then this can also later happen.

top

Image pickup 1 and graphic data bank 8

The image pickup and the graphic data bank 8 serve a sample for the detection and archiving of the image data. This concerns the learning enterprise, in which the images become the corresponding decision classes associated, which that so-called. monitored learning corresponds. Representative patterns of all classes will be to h collected and thus in the subsequent processing steps at any time again at the disposal. Thus the Parametrieren of the Klassifikators knows off-line, D after collecting the sample also. h. without operation of the image pickup device, performed become. This is for the applications of manufacturing of critical importance, since a collecting of the patterns and training the Klassifikators may interrupt to the learning production not arbitrary and therefore a frequent representative selection of sample pictures only off-line possible is.

Characteristic extraction 2

In the unit 2 for characteristic extraction the made preprocessing and information reduction (data reduction, reduction of the cost of computation) of the extensive image data on the substantial picture characteristics. It takes place the clock times in production processes necessary information reduction, fast for observance. The selection of the features is a substantial conclusion to the solution of the task of recognition. Thus for example fully automatic suitable picture characteristics for the Klassifikator become selected of a test program of the image processing system, created of the user.

Characteristic data base 3

With the learning all picture characteristics defined in the test program become from the images extracted and collected in the characteristic data base from all images of the learning sample. The subsequent processing stages access only the characteristic data base. The test program becomes automatic with the classification parameters supplemented calculated in the subsequent processing steps. Thus various Klassifikati DP< N= 7 can >become onsverfahren used. The learning mode can become at any time interrupted, in order to add for example still new decision classes.

Normalization 4

A significant problem with most classification procedures is the question of the proper scaling of the features. This wise usually no uniform range of values up and affect by it the Klassifikator. Made according to invention in this processing stage a normalization of the characteristic area on an uniform metric (entire record). All elements fi the feature vector f are scaled therefore on the basis the calculated extreme values in the record on an uniform area, for example from 0 to 1. The extreme values are for example minimum and maximum of each feature. This can become mathematical shown as follows:
EMI7.1

By the fact is ensured that the Klassifikator works uninfluenced by the actual range of values of the features.

Sample reduction 5

The sample should contain if possible a representative selection of all decision classes. Since this requirement is only heavier realizable, our invention plans a collecting as much as possible images in the learning sample. Similar patterns, which would not in particular lower additional informations over the characteristic distributions to contain and with complex tasks of pattern recognition with many various sample classes in a high-dimensional characteristic area the processing speed unnecessary manner, become again eliminated therefore in this step. The sample reduction is therefore a substantial flagstone of the invention for the conversion of the method to industrial Anwendurigen. The characteristic distance becomes D I for the entire< sample> a pattern as follows calculated:
EMI8.1

This distance falls below D< I> for all features a defined limit dmin, D. h. is D< I> < dmin, then the pattern is considered as another similar and becomes from the sample remote. With sufficient large number of available patterns the allowable limit can become also automatic from the sample statistics certain.

Case similar patterns from various decision classes to be found, is the representation of the object classes in the characteristic area incomplete. The automatic learning enterprise will thus interrupted and the characteristic area must extended become and/or. the division of the decision classes must become corrected. Around an independence of the particular Merkmalsmetrik to obtained, the similarity in the normalized characteristic area becomes measured.

Characteristic reduction 6

In the characteristic data base 3 all extracted picture characteristics deposited become in the learning enterprise. Since the test program usually contains a variety of features, z. B. to the position determination, however no information for classifying contained is the automatic selection of relevant features a substantial flagstone of the invention. Target of the characteristic reduction is more significant therefore the selection and not significant features for classifying and partial recognition.

As measure for the significance of a feature becomes the average distance feature it all decision classes (interset distance) as good ASS Ji defined:
EMI8.2

EMI9.1
K number of the decision classes
Mk number of the patterns in decision class k
fi feature i von Muster/
// . . . // spacer measure

Ever large this value is, so much the better can a class discriminated on the basis the considered feature become. Features their significance is small, becomes eliminated. From the significance of the single characteristics the automatic for classifying suitable features become selected and in the test program characterized. Classifying a pattern only the significant features become used from all calculated features.

Klassifikator

The features remaining after the characteristic reduction 6 become a classification algorithm supplied. This has the object to determine the class affiliation of an unknown pattern. Paths of the insufficiently known signal statistics of the features statistical methods are usually less suitable for classifying. As classification procedures nebe neural networks have themselves in particular the k next neighborKlassifikator (KNN Klassifikator) preserved. The latter required contrary to other classification procedures assumptions over the statistical distribution in the characteristic area and does not supply therefore also with a small number of patterns in the learning sample good results. The distance of a pattern becomes all patterns contained in the sample calculated and the membership on the basis the patterns with the k-smallest distances certain over a metric. As spacer measure the Euclidean distance becomes usually used.

With the learning made after the sample and characteristic reduction a complete test of the Klassifikators. Each pattern, whose class affiliation is known, contained in the sample, becomes classified. The ratio of the number of the proper decisions to the accomplished number of classifying the defined reliability of the Klassifikators. With insufficient reliability the features are not sufficient and must supplemented become.

Learning 9

In the learning enterprise made training of the Klassifikators by the presentation of a sample with the images of all decision classes which can be separated. The Klassifikator automatic is parametriert and is in the layer to assign unknown patterns to the present first fixed decision classes.

The method is suitable for classifying problems in the image processing of all type (divisor identification, quality control. . .). The k-next-neighbor-Klassifikator has itself in particular for the objects with a high-dimensional characteristic area preserved. With these applications a Clusterung in the characteristic area analytic is to be determined only heavier, so that decision-theoretical based Klassifikatoren is not more insertable. The methods for the sample and characteristic reduction make an application of this Klassifikators also in time and for resource-critical applications of manufacturing possible. By the modular structure of the system however also different Klassifikatoren and neural networks can become used. In the comparison to the KNN Klassifikator grant neural networks a defined processing time for classifying, need however a substantial longer learning phase, while the processing time depends with the KNN Klassifikator on the number of the too remaining patterns.

Applications of the invention concern methods for universal standard image processing systems, for example in the automotive manufacture or in the wood industry. First machines became already successful tested. Reference symbol list
K, L, M decision class
f, f1. . . 3, I< A> Feature vector
i, I, m run indices
1 unit to the image pickup

2 unit for characteristic extraction
3 characteristic data base
4 unit to the normalization
5 unit for automatic sample reduction
6 unit for automatic picture characteristic reduction
7 unit for automatic classifying
8 graphic data bank
9 learning unit
10, 11 loop